National Aeronautics and
Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

Recent Science Highlights
-and-
Summary Report from the November Sounder Science Workshop

Eric J. Fetzer

Jet Propulsion Laboratory / California Institute of Technology

AIRS Science Team Meeting, Caltech

April 26-29, 2011

National Aeronautics and Space Administration

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California Institute of Technology
Pasadena, California

In Memory of Dr. Mous Chahine

AIRS Science Team Leader and Friend

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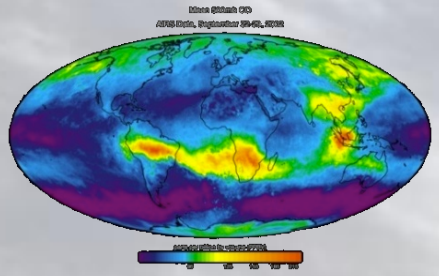
AIRS Key Products and Science Areas

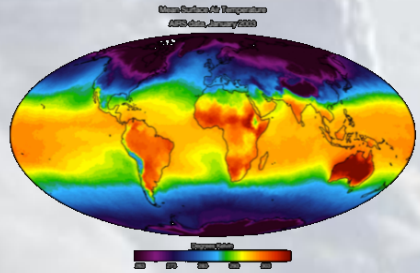
CO



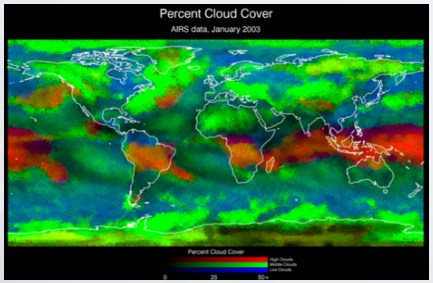
Greenhouse Gas Forcing

Cloud and Water Vapor Processes

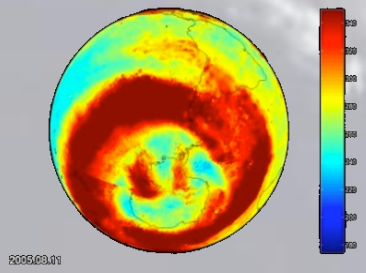
Atmospheric Temperature



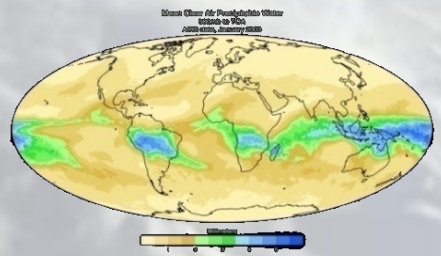
Cloud Properties



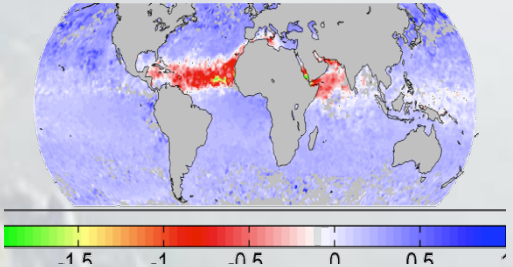
Ozone



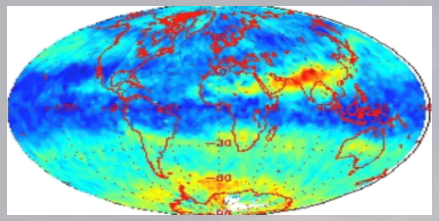
Atmospheric Water Vapor



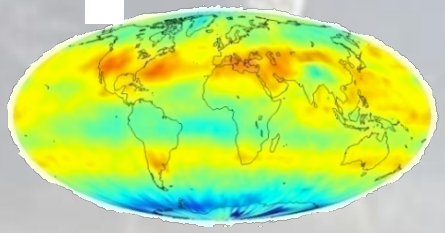
Dust



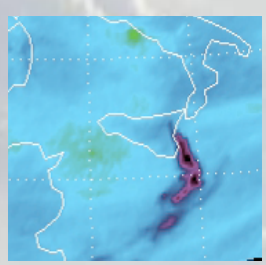
Methane



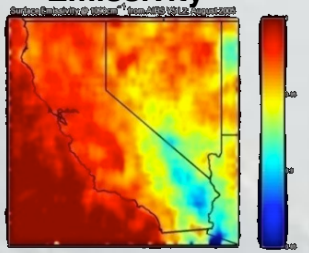
CO2



SO2



Emissivity



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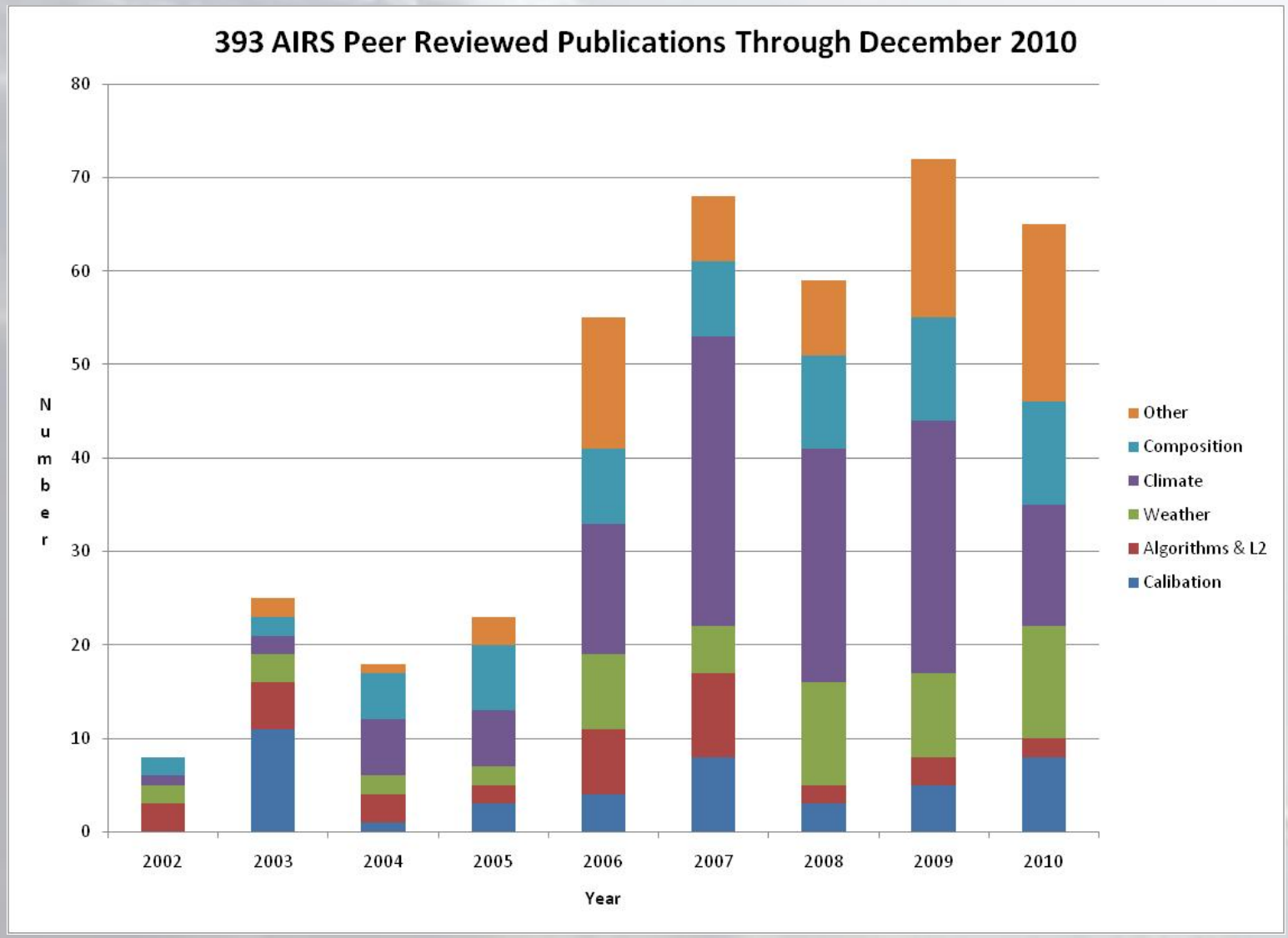
400+ AIRS Peer-Reviewed Publications



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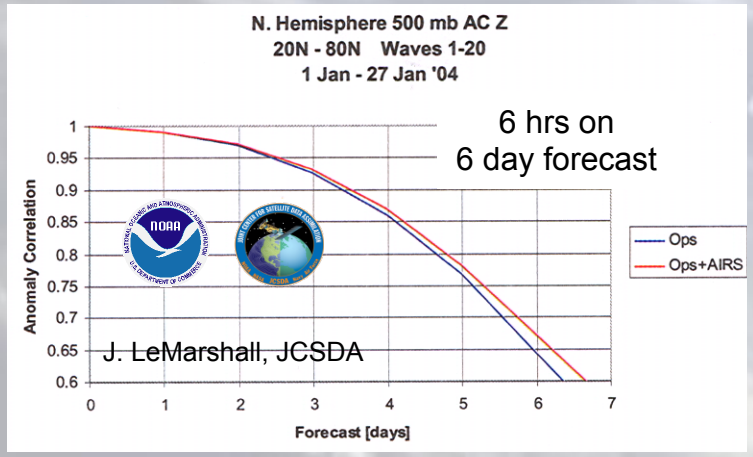
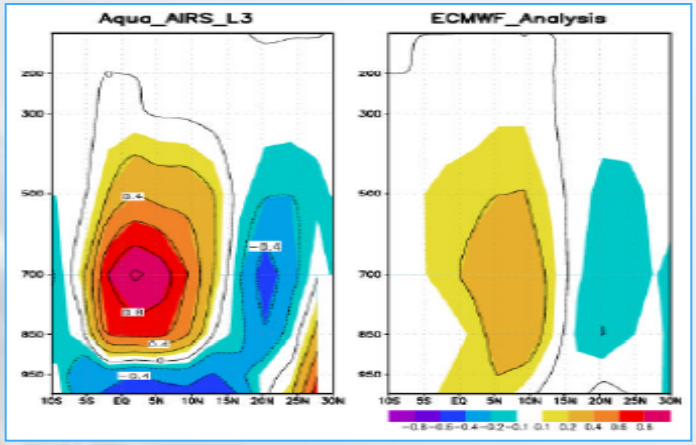
AIRS Improves Weather Operations and Research

NCEP Operational Improvement

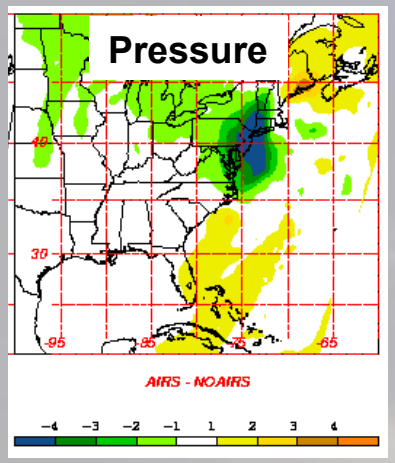


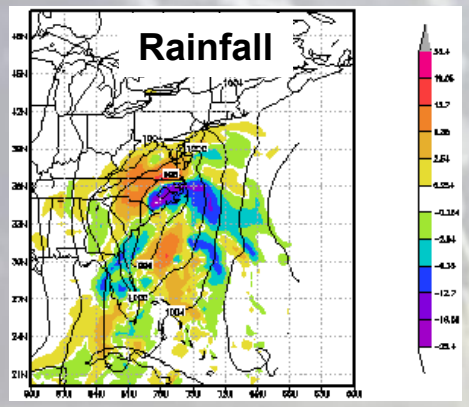
AIRS Research Validates Models



J. Fu, U of Hawaii

Regional Forecast Improvement

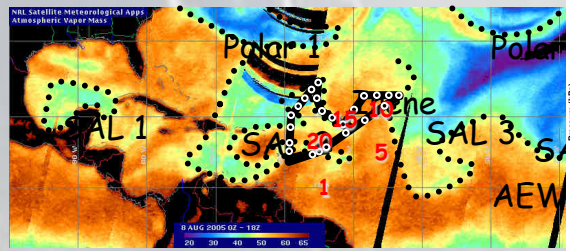


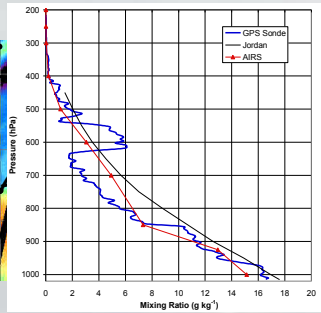


B. Zavodsky, NASA SPoRT

NOAA Hurricane Center

Saharan Air Layer Hurricane Suppression





J. Dunion, NOAA

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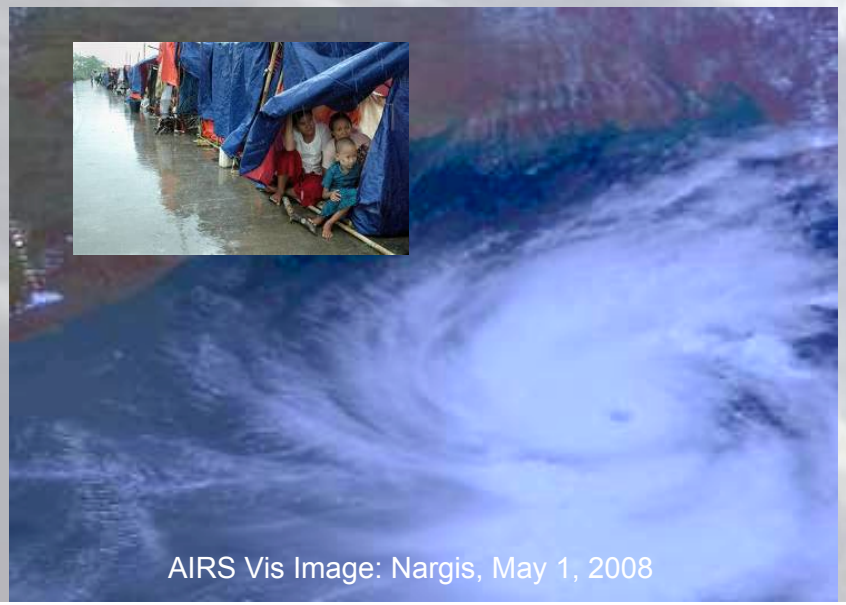
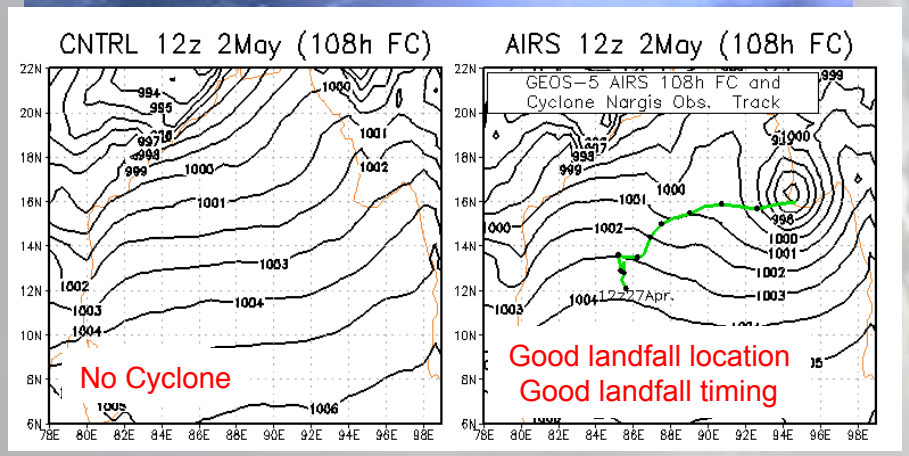
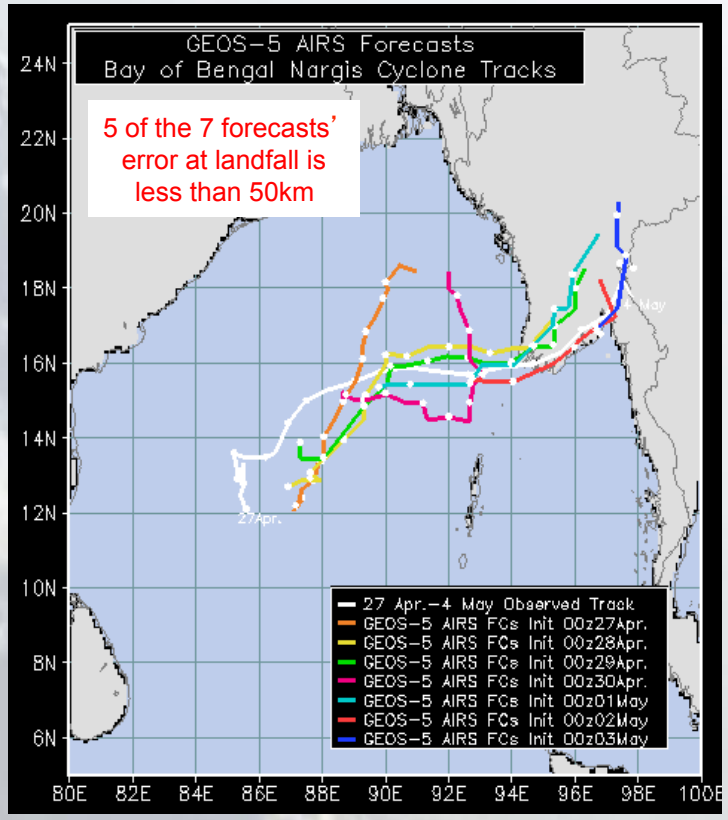
Information from AIRS *Retrievals* in Cloudy Regions Improves Tropical Cyclone Forecasts

Major Impact to Tropical Cyclone Nargis Hindcast







Reale, O., W. K. Lau, J. Susskind, E. Brin, E. Liu, L. P. Riishojgaard, M. Fuentes, and R. Rosenberg (2009), AIRS impact on the analysis and forecast track of tropical cyclone Nargis in a global data assimilation and forecasting system, *Geophys. Res. Lett.*, 36, L06812, doi: 10.1029/2008GL037122. http://www.agu.org/journals/gl/gl0906/2008GL037122/

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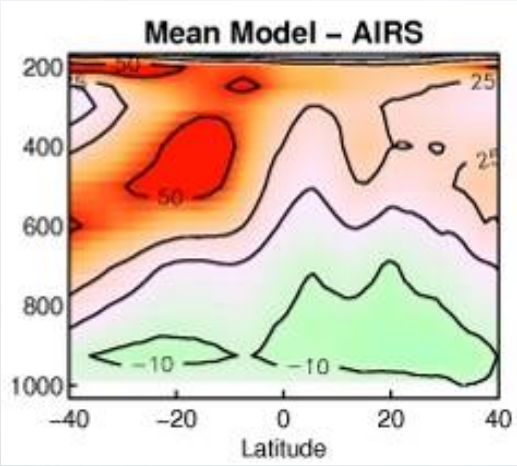
AIRS Finds Biases in Climate Model Moisture & Temperature

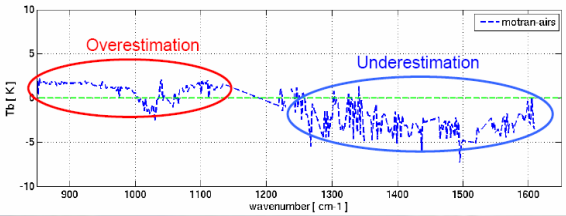
- **AIRS finds major climate models are too dry below 800 mb in the tropics, and too moist between 300 mb and 600 mb especially in the extra-tropics. (Pierce, John, Gettleman); too cold above.**
- ***Radiance biases of opposite signs in different spectral regions suggests that the apparent good agreement of a climate model's broadband longwave flux and total water with observations may be due to a fortuitous cancellation of spectral errors (Huang).***



Water Vapor
Vertical Climatology
(Pierce, Scripps)

1. *Pierce D. W., T. P. Barnett, E. J. Fetzer, P. J. Gleckler (2006), Three-dimensional tropospheric water vapor in coupled climate models compared with observations from the AIRS satellite system, Geophys. Res. Lett., 33, L21701, doi:10.1029/2006GL027060.*
2. *John, V.O. and Soden, B. J. (2007), Temperature and humidity biases in global climate models and their impact on climate feedbacks, Geophys.Res. Lett., 34, L18704, doi:10.1029/2007GL030429*
3. *Gettleman, Collins, Fetzer, Eldering, Irion (2006), "Climatology of Upper-Tropospheric Relative Humidity from the Atmospheric Infrared Sounder and Implications for Climate", J. Climate, 19, 6104-6121. DOI: 10.1175/JCLI3956.1*
4. *Huang, Y., Ramaswamy, V., Huang, X.L., Fu, Q., Bardeen, C. (2007), A strict test in climate modeling with spectrally resolved radiances: GCM simulation versus AIRS observations, Geophys. Res. Lett.,, 34, 24, L24707*

Unit: W m^{-2}	OLR		Window band	
	Total sky	Clear sky	Total sky	Clear sky
CERES	241.73	275.87	66.94	83.28
AM2	240.63	263.43	73.99	87.56
AM2-CERES	-1.10	-12.44	7.05	4.28



Outgoing Longwave Radiation
(Huang, Univ. of Michigan)

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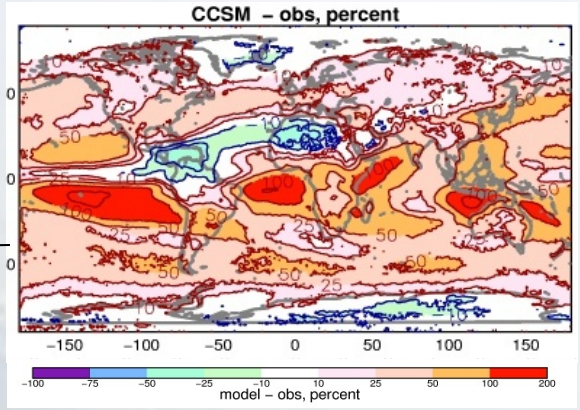
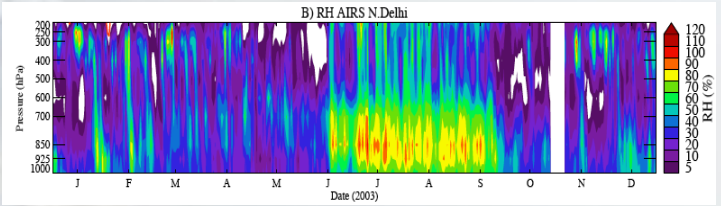
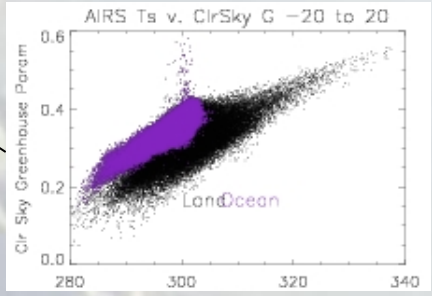
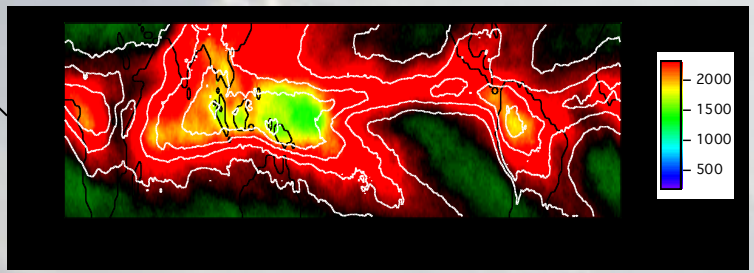
AIRS H_2O Data used as "Truth" to Improve Parameterizations in Climate Models

- **Tim Barnett: Scripps, UCSD**
  - *Coupled Climate Models show >50% bias errors in H2O vapor. Models worst at mid altitude and mid latitude.*
- **Andrew Gettleman: NCAR**
  - *AIRS can provide insight on climate forcings*
  - *Variability not well reproduced in GCM/CAMS*
  - *Greenhouse effect appears to increase with SST*
  - *Water vapor feedback positive: but not as positive as constant RH would assume*
- **Andrew Dessler: Texas A&M**
  - *Simple trajectory model with fixed RH limit does a good job of reproducing AIRS annual average water vapor*
  - *Model shows that dehydration of mid-troposphere air occurs in three latitude bands*

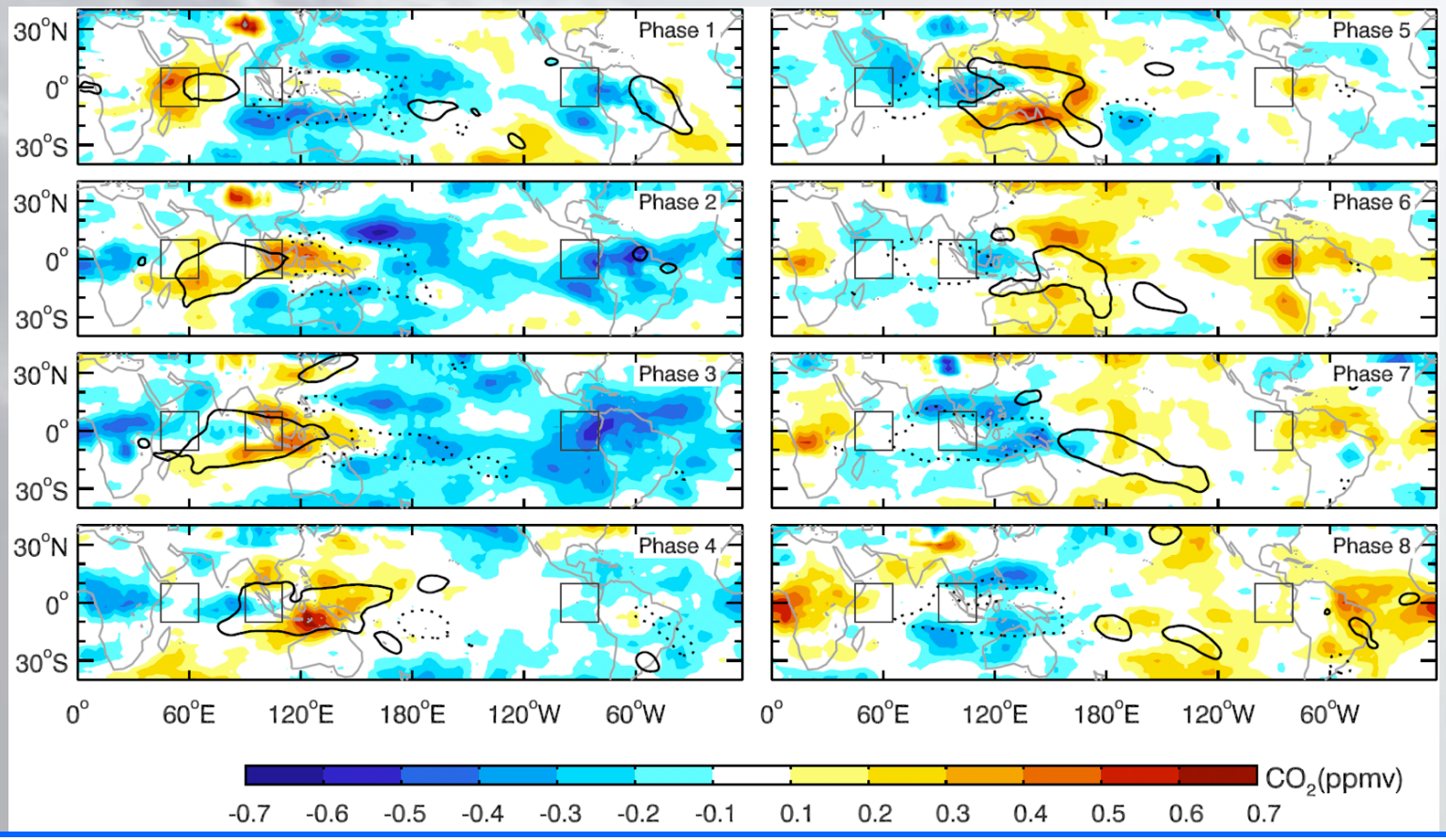








Atmospheric Composition: Influence of Madden-Julian Oscillation on AIRS CO_2



Contour line: TRMM Rain

AIRS CO2 data are modulated by the Madden-Julian Oscillation. The peak-to-peak amplitude of the MJO signal is ~ 1 ppm.

Li et al. [PNAS, 2010]

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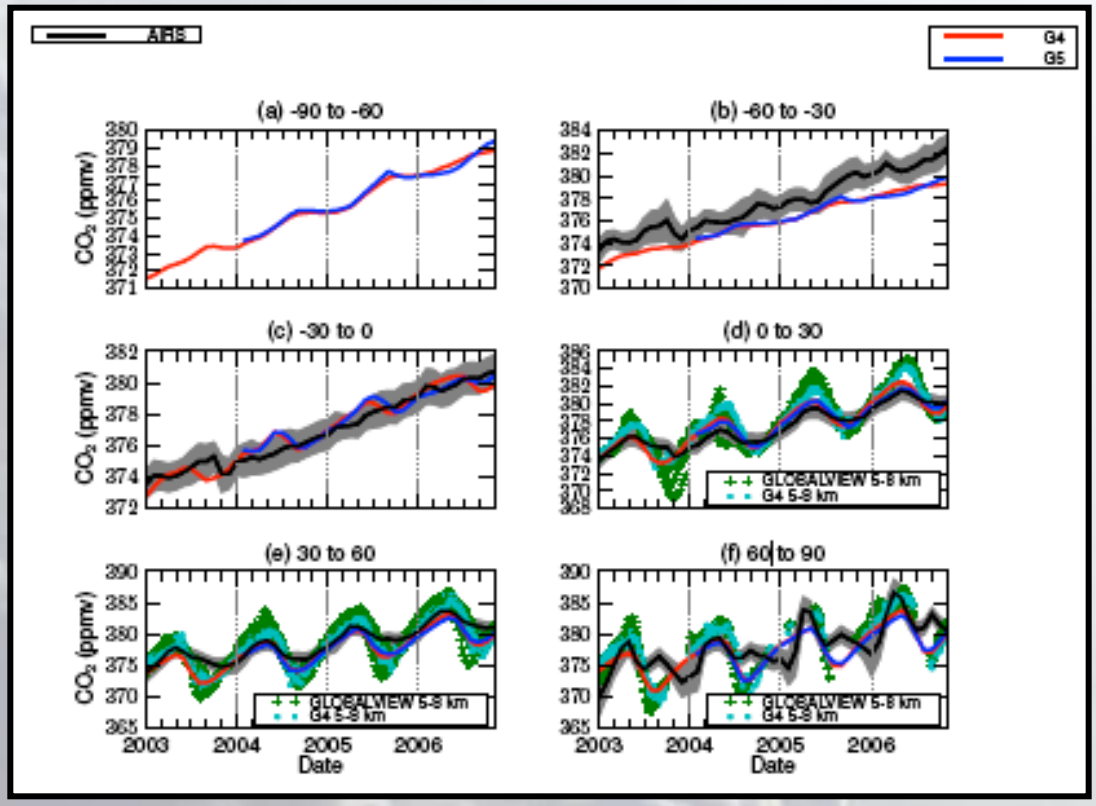
AIRS CO_2 Constraining Chemistry Models



Monthly-mean AIRS (black) and a posteriori model (red GEOS-4 and blue GEOS-5) CO2 concentrations (ppm) averaged over 30 degree latitude bins during 2003–2006: (a) 60 S–90 S, (b) 30 S–60 S, (c) 0–30 S, (d) 0–30 N, (e) 30 N–60 N, and (f) 60 N–90 N. The GEOS-Chem model, described at a horizontal resolution of 2 ° 2.5, has been sampled at the time and location of each AIRS level-3 CO2 scene, weighted by the observation numbers, and convolved using the vertical weighting functions from Chahine et al. (2008).

Feng, L., Palmer, P. I., Yang, Y., Yantosca, R. M., Kawa, S. R., Paris, J.-D., Matsueda, H., and Machida, T.: Evaluating a 3-D transport model of atmospheric CO_2 using ground-based, aircraft, and space-borne data, *Atmos. Chem. Phys., 11,* 2789-2803, doi:10.5194/acp-11-2789-2011, 2011.

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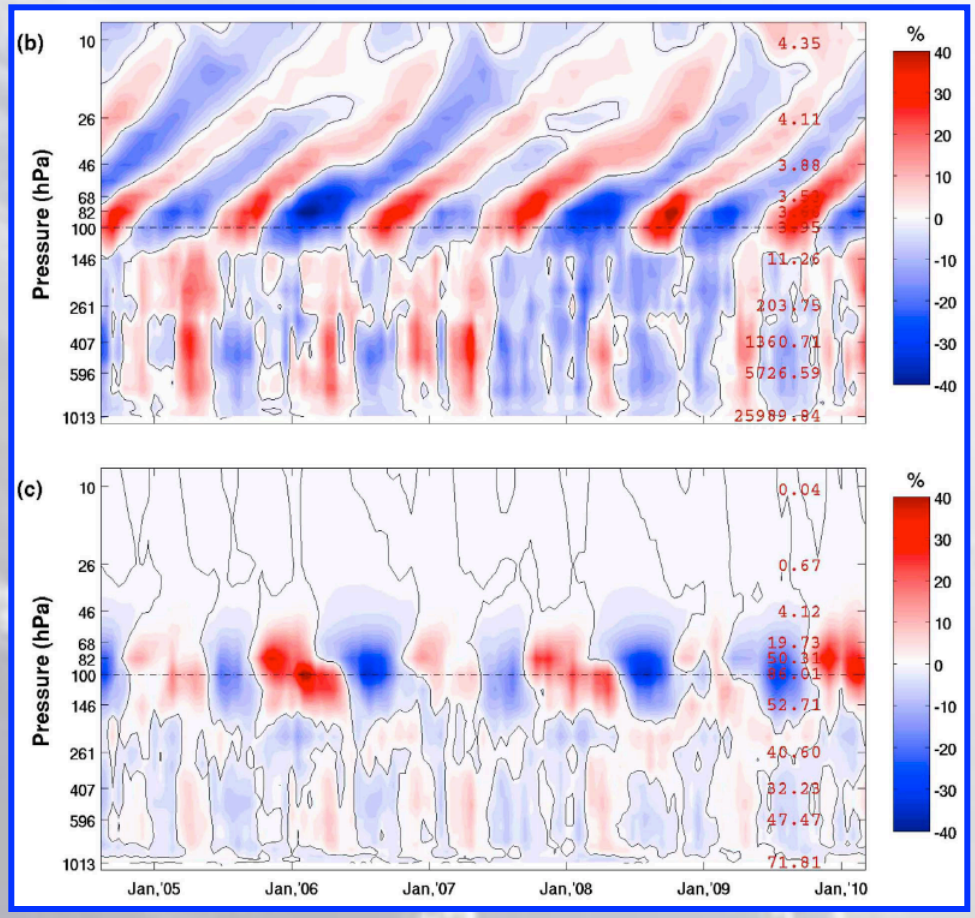
AIRS and MLS give complete picture of atmospheric water vapor



Equatorial mean (08°S–08°N, 180°E–180°W) time evolution of (b) water vapor (%), and (c) RH (%) with the time record mean removed at each pressure level.

Liang, C. K., A. Eldering, A. Gettelman, B. Tian, S. Wong, E. J. Fetzer, and K. N. Liou (2011), Record of tropical interannual variability of temperature and water vapor from a combined AIRS-MLS data set, *J. Geophys. Res., 116,* D06103, doi:10.1029/2010JD014841.

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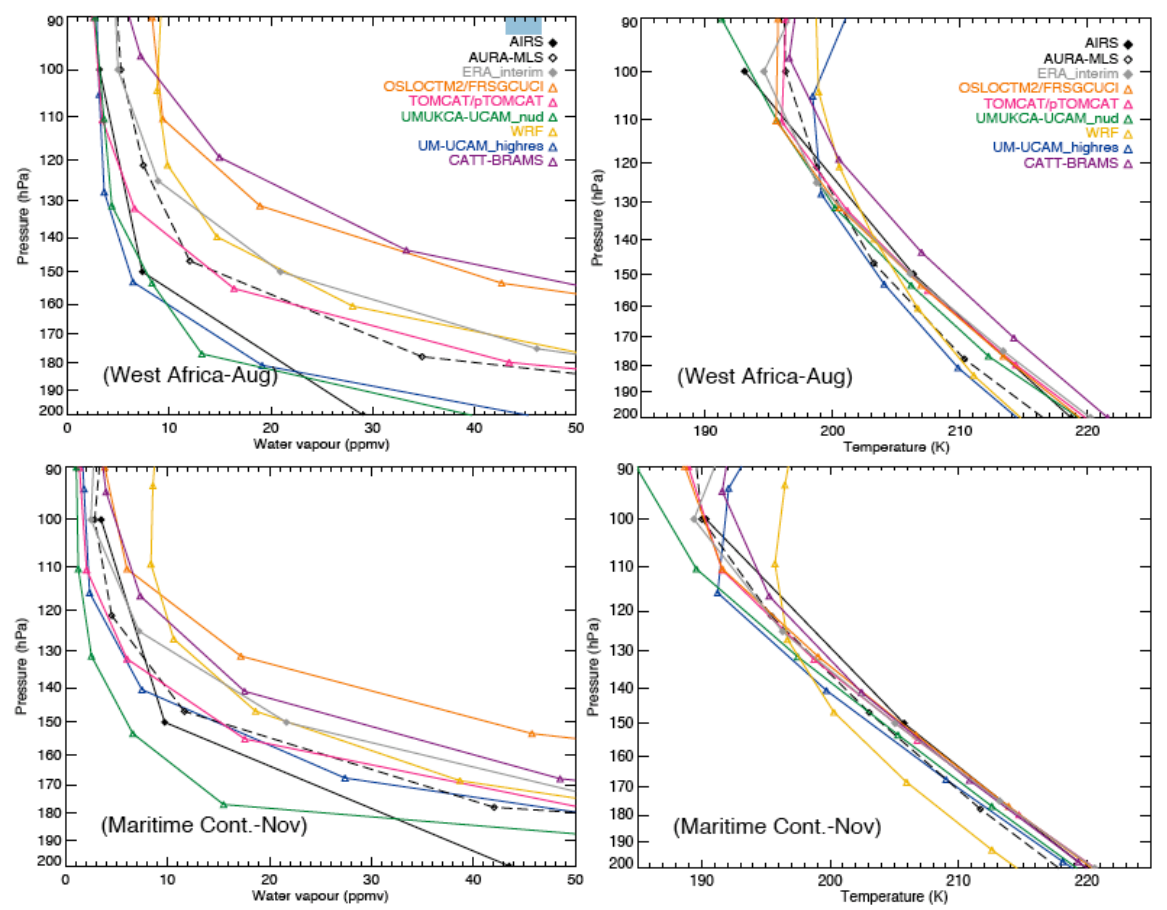
AIRS Validates Upper Tropospheric Water Vapor and Temperature in Models

Weather and climate model upper tropospheric water vapor and temperature.



Russo, M. R., Marécal, V., Hoyle, C. R., Arteta, J., Chemel, C., Chipperfield, M. P., Dessens, O., Feng, W., Hosking, J. S., Telford, P. J., Wild, O., Yang, X., and Pyle, J. A.: Representation of tropical deep convection in atmospheric models – Part 1: Meteorology and comparison with satellite observations, *Atmos. Chem. Phys., 11,* 2765-2786, doi:10.5194/acp-11-2765-2011, 2011.

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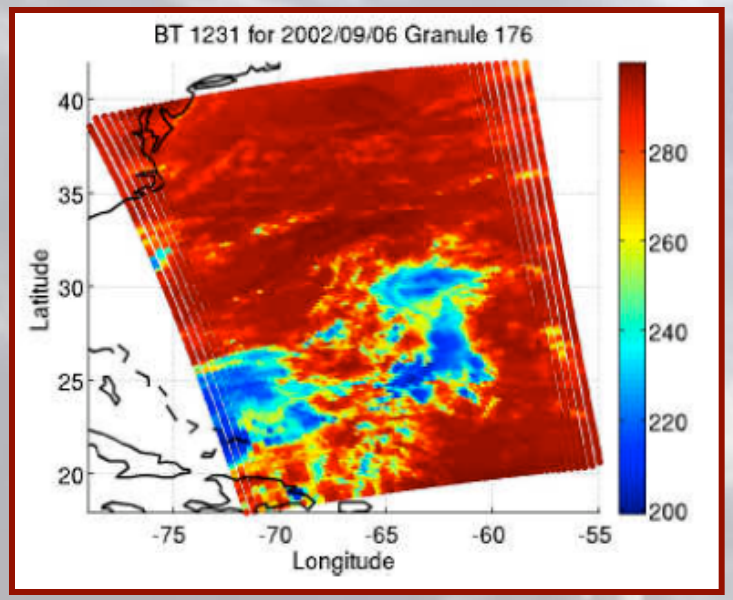
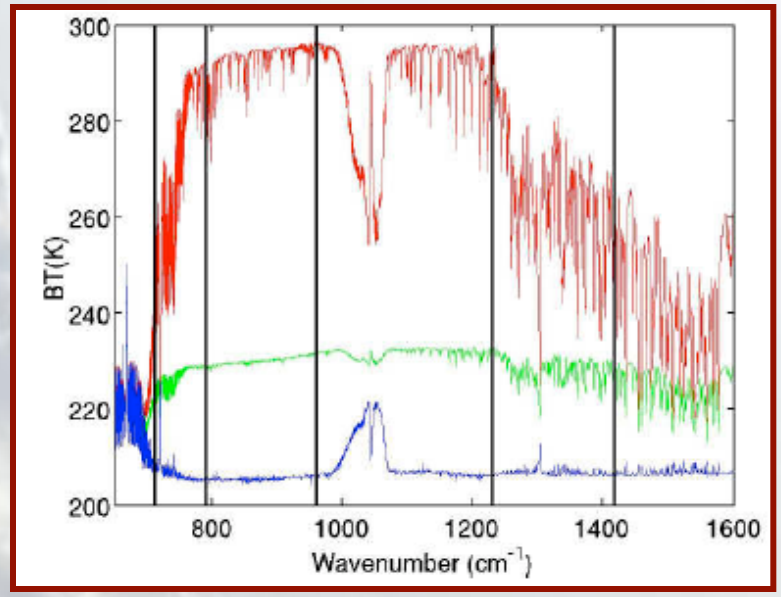
Observations of Deep Convective Clouds





Aumann, H. H., DeSouza-Machado, S. G., and Behrangi, A.: Deep convective clouds at the tropopause, *Atmos. Chem. Phys., 11,* 1167-1176, doi:10.5194/acp-11-1167-2011, 2011.

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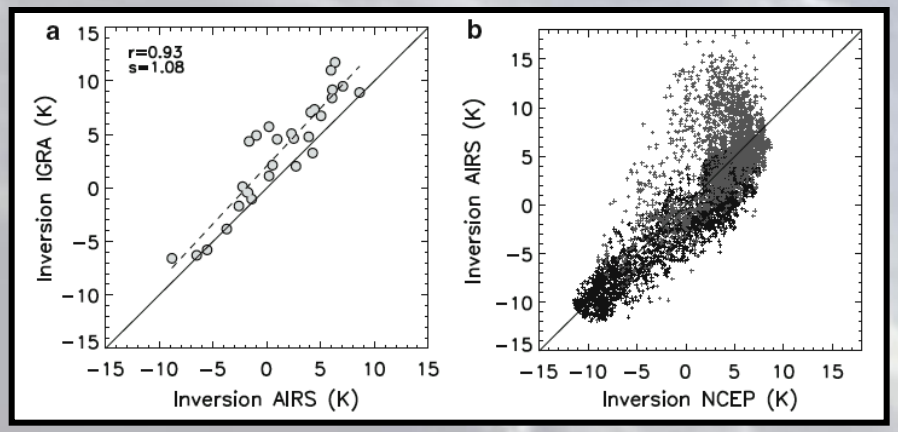
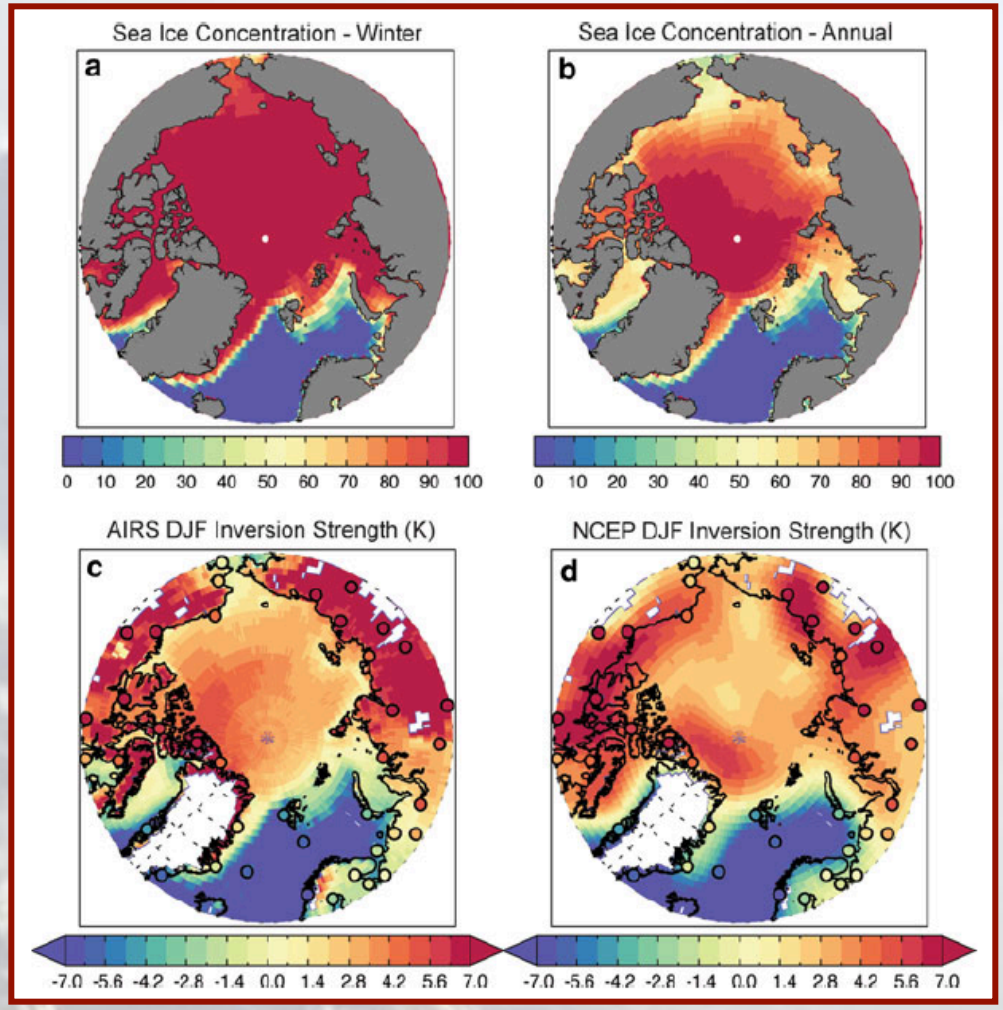
Temperature Inversions and Winter Sea Ice



AIRS inversions well validated with radiosondes.



Sea Ice (top) and Inversions (Bottom)

Pavelsky, T., J. Boé, A. Hall, E. J. Fetzer (2011), Atmospheric inversion strength over polar oceans in winter regulated by sea ice, *Clim. Dyn.*, *36*, 945–955.

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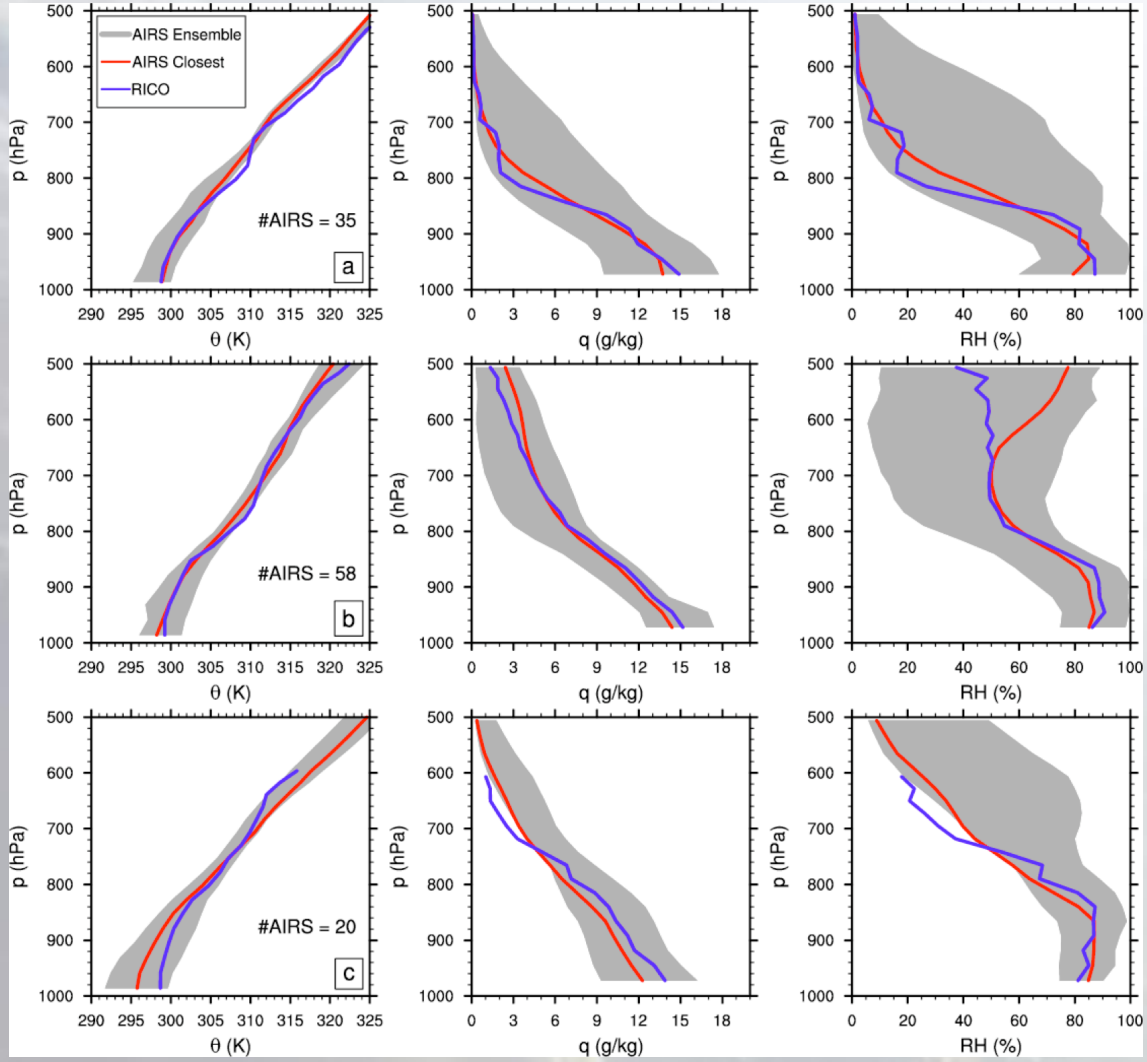
IR sounding and cumulus boundary layer vertical structure: AIRS and RICO experiment



Martins, J. P. A., J. Teixeira, A. F. Santos, P. M. M. Soares, P. M. A. Miranda, V. Dang, F. W. Irion, E. Fetzer, and E. F. Fishbein, Martin, M. J. P. A, (2010), Infra-red Sounding of the Trade-wind Boundary Layer: AIRS and the RICO Experiment, *Geophys. Res. Lett.*, 37, L24806, doi:10.1029/2010GL045902.

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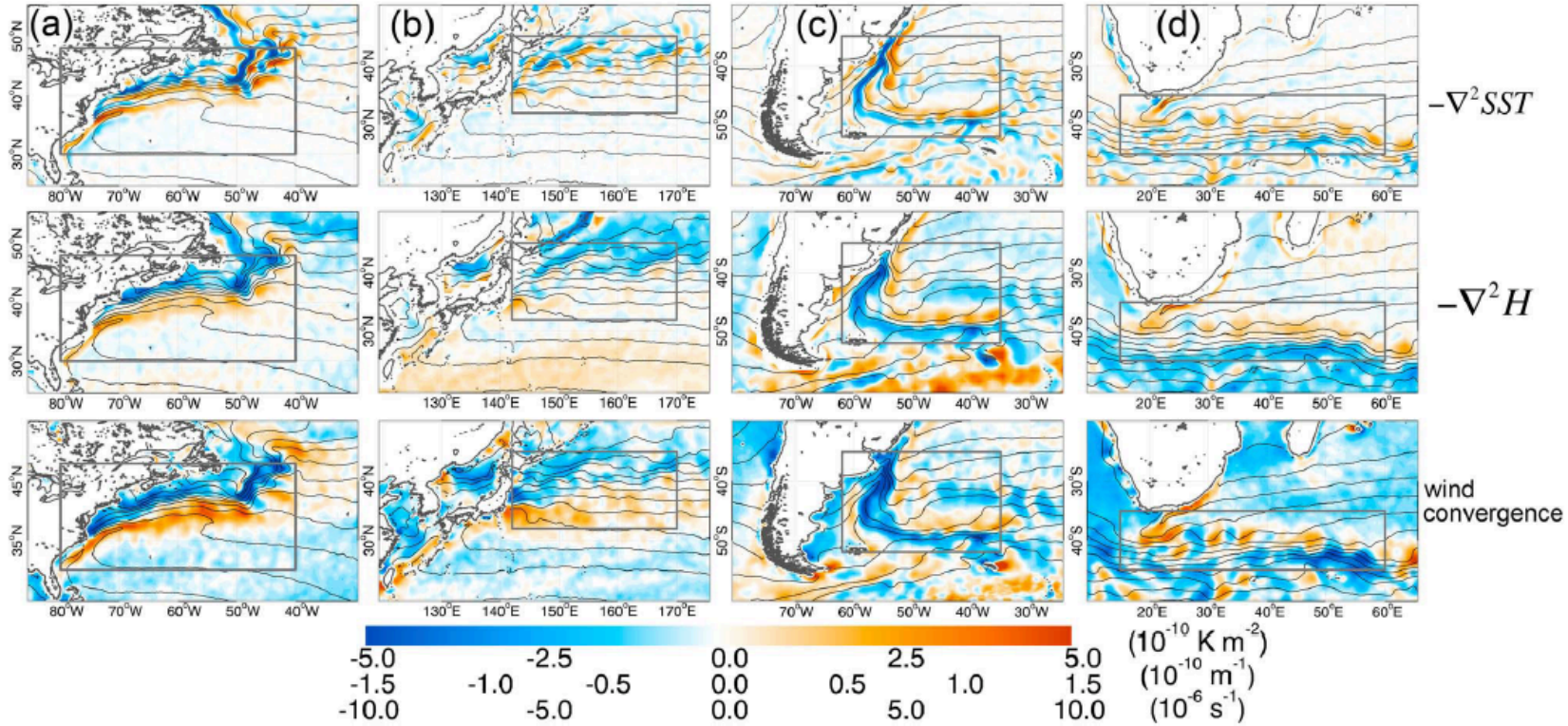
Observations of air-sea interactions over ocean fronts

AMSR-E SST Laplacian

AIRS thickness (850-1000 hPa) Laplacian

QuikSCAT wind Laplacian



Shimada, T., and S. Minobe (2011), Global analysis of the pressure adjustment mechanism over sea surface temperature fronts using AIRS/Aqua data, *Geophys. Res. Lett., 38,* L06704, doi:10.1029/2010GL046625.

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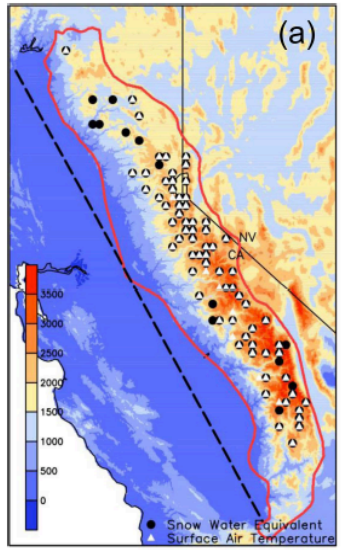
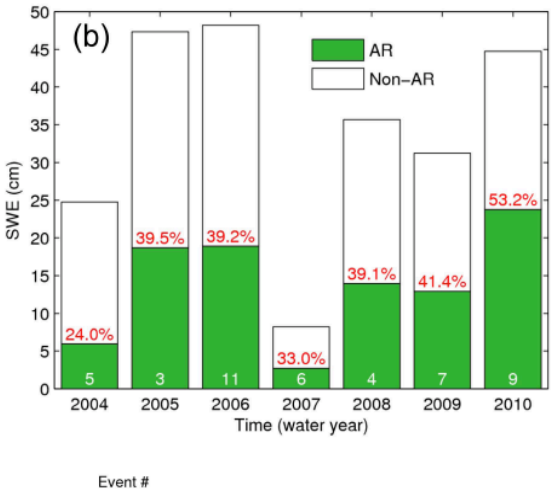
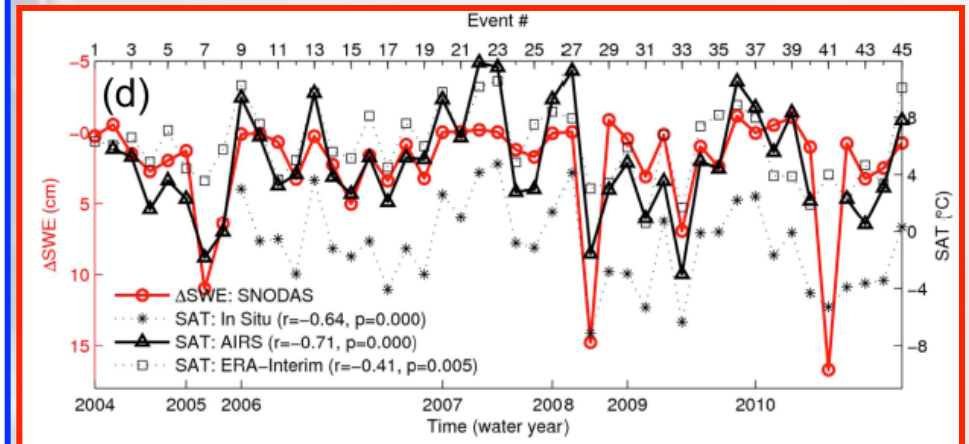
Sierra Snowfall Correlates with AIRS Surface Air Temperature *but not weather models*







Sierra snowfall (red) better correlated with surface air temperature from AIRS (thick black) than ECMWF (black boxes).

Guan, B., N. Molotch, D. Waliser, E. Fetzer and P. Neiman (2010), The sensitivity of snow accumulation in the Sierra Nevada to atmospheric river landfalls and local surface air temperatures, *Geophys. Res. Lett.*, *37*, L20401, doi:10.1029/2010GL044696.

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NASA Science Community Workshop on Polar Orbiting IR and MW Sounders

- **Held November November 1st and 2nd, 2010 in Greenbelt, MD.**
  - ***The two days prior to the last AIRS science team meeting.***
- **Over 70 participants from the U.S., Europe, and Japan**
  - ***NASA***
  - ***NOAA***
  - ***EUMETSAT***
  - ***CNRS***
  - ***Universities***
- **Four sessions:**
  - ***Plenary***
  - ***Weather breakout***
  - ***Climate breakout***
  - ***Composition breakout***

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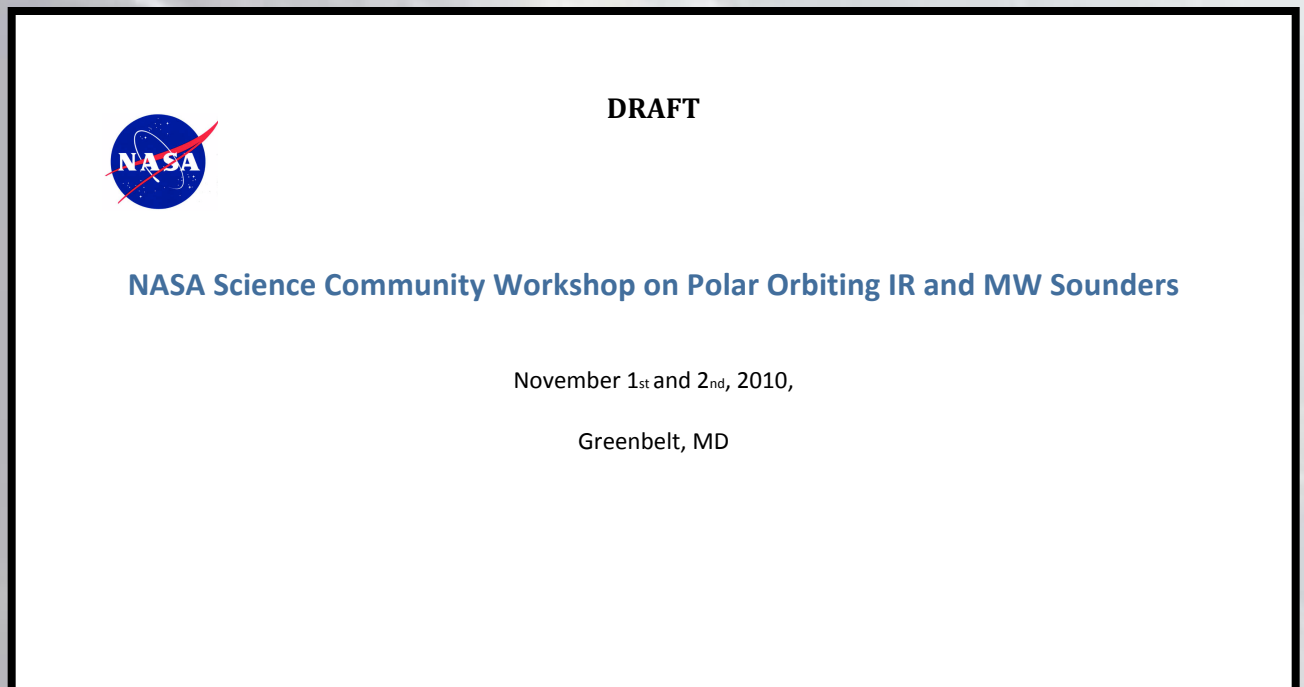
A Draft Report with Recommendations is available

- ***Authors***: **Tom Pagano, Joel Susskind, Kevin Bowman, Chris Barnet, Eric Fetzer**

- ***Contents***: **Objectives, Executive Summary, Overview of Sessions, Summary of Recommendations.**

- **Critics love it.** ***"I'm impressed!" –B. Kahn***



DRAFT

NASA Science Community Workshop on Polar Orbiting IR and MW Sounders

November 1st and 2nd, 2010,

Greenbelt, MD

National Aeronautics and Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

Recommendations
Lots more in the report

Primary Recommendations

Recommendation I: The formation of a US based Sounding Science Team is required to identify the current and future needs of the weather, climate and atmospheric composition communities using data from the IR and MW sounders.

Recommendation II: The JPSS enable the full spectral resolution possible with the FM-1 CrIS on NPP as soon as possible.

Recommendation III: NASA should begin development of an advanced IR sounder with high spatial resolution and improved spectral resolution to be ready to follow the current planned sounders expected to retire in the 2020 timeframe.

Detailed Session Recommendations

SESSION 1: Climate

Recommendation 1.1.1: The value of monitoring long-term variability and extreme climate events should be emphasized in all sounding systems.

Recommendation 1.1.2: Further research to generate new and improved products from AIRS and IASI is needed, especially with regard to cloud and dust microphysical and radiative properties. Improved theoretical techniques are needed for multiple scattering at finer spatial resolution.

Recommendation 1.1.3: Fully characterize IASI performance with increasing cloud cover, using AIRS as baseline. Evaluate 3+ years of IASI products generated by NOAA using an AIRS science team-like algorithm. Compare interannual differences and trends obtained from AIRS and IASI products. Repeat this experiment using a NOAA IASI retrieval algorithm when it becomes available.

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Conclusions

- **Enormous breadth to AIRS research**
  - ***Reflected in ~400 publications mainly in***
    - Weather.
    - Climate.
    - Atmospheric Composition.

- **Sounder Science Workshop held in November**
  - ***Expect a final workshop report very soon.***